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TRACE ELEMENTS IN ANTARCTIC METEORITES: WEATHERING AND GENETIC INFORMATION; M. E. Lipschutz, Dept. of Chemistry, Purdue University, W. Lafayette, IN 47907 USA.

Antarctic meteorite discoveries have created great scientific interest due to the large number of specimens recovered (~7000 so far) and because they include representatives of hitherto rare or unknown types. Some can be paired, on average 2-6/event [1]: these 1200-3500 separate Antarctic meteorites form a population comparable to the 2611 known non-Antarctic meteorites [2]. Antarctic meteorites are so abundant because they have fallen over long periods ($\leq 7 \times 10^5$ years, averaging 3×10^5 years in Victoria Land) and have been preserved, transported and concentrated by the ice sheet [3].

Differences between the Antarctic and non-Antarctic sample populations are evident at various subtlety levels, even at the least subtle (Table 1) [4]. Antarctic meteorites are therefore a potentially unique source of genetic information provided that weathering during terrestrial residence in or on the ice sheet can be accounted for or is negligible.

Antarctic meteorites (stones, in particular) are classified by macroscopic (and fracturing) characteristics into 3 types, A-C, ranging from essentially unaltered to very heavily weathered. Meteoritic compositions should reflect terrestrial weathering unless it occurs in situ so that elements are neither gained nor lost, i.e. the system is closed. Trace element contents should be particularly instructive since even a small absolute amount of chemical transport should result in large relative compositional changes.

The few studies thus far indicate that Antarctic meteorite weathering essentially involves closed systems. Lipschutz [5] reviewed data published in 1980 and earlier - mainly for uncommon meteorites of weathering types A and B. Provided that interior samples (>0.5 cm below the meteorite's surface) are used, compositions of Antarctic finds and non-Antarctic falls of uncommon type accord well, although analytical ranges for the falls can be extended by data for Antarctic finds.

More recently, weathering effects on trace element contents of H5 chondrites have been studied in detail [4,6]. Of 13 elements studied, 5 are more abundant in weathering type A and B H5 chondrites than in those of type C: Bi and Cs differ at significant ($>95\%$ confidence) levels, Co, Sb and Tl at possibly significant (90-94%) ones. For 3 samples with weathering rinds, interior samples contain significantly more Cs and possibly Te than do rinds: these seem attributable to chance. ALH A82102, an H5 chondrite caught emerging from the ice, reveals no systematic difference between exposed and submerged portions beyond that attributable to chance. As proposed earlier [5], these more recent data suggest leaching as the primary Antarctic weathering process for H5 chondrites and, presumably, others. The effects are, however, minor and, with proper precautions, data from Antarctic meteorites are as reliable as those obtained from non-Antarctic falls [5]. Interestingly, trace and major element dispersion is generally smaller in Antarctic samples than in non-Antarctic falls [4, 6-8].

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Table 1. Comparative numbers of selected meteorite types * found in Victoria Land and falling in non-Antarctic regions

| Meteorite Type | Victoria Land | | Non-Antarctic | |
|----------------|---------------|-------|---------------|-------|
| | No. | Pct. | No. | Pct. |
| Chondrites | 756 | 92.4 | 784 | 86.6 |
| H | 542 | 66.3 | 276 | 30.5 |
| L | 167 | 20.4 | 319 | 35.2 |
| LL | 24 | 2.9 | 66 | 7.3 |
| Achondrites | 45 | 5.5 | 69 | 7.6 |
| Irons | 14 | 1.7 | 42 | 4.6 |
| Stony Irons | 3 | 0.4 | 10 | 1.1 |
| Total | 818 | 100.0 | 905 | 100.0 |

* Data from sources listed by Dennison et al. [4]. Queen Maud Land (Yamato) samples and non-Antarctic finds also exhibit the same trends: deficiencies of LL chondrites, irons and stony-irons and a very high H/L chondrite ratio in Antarctic meteorites compared with non-Antarctic ones [4].

Table 2. Comparison of statistically significant differences in H5 and L6 chondrites from Victoria Land, Antarctica with contemporary non-Antarctic falls [4,8].

| Element | H5 [†] | | | Element | L6 [†] | | |
|----------|-----------------|---------|------|----------|-----------------|---------|------|
| | Ant.(23) | Non(20) | Sig. | | Ant.(13) | Non(25) | Sig. |
| | | | | Co(ppm)* | 480 | 600 | 97 |
| | | | | Au(ppb)* | 140 | 160 | 90 |
| Sb(ppb)* | 83 | 69 | 97 | | | | |
| Se(ppm) | 9.0 | 8.2 | 99 | | | | |
| Rb(ppm) | 2.0 | 2.5 | 97 | Rb(ppm) | 2.6 | 2.2 | 95 |
| | | | | Cs(ppb) | 4.02 | 12.4 | 99 |
| | | | | Te(ppb) | 340 | 380 | 90 |
| Bi(ppb) | 2.8 | 1.1 | 98 | Bi(ppb) | 0.58 | 2.7 | 99 |
| | | | | Ag(ppb) | 45 | 71 | 97 |
| In(ppb) | 0.21 | 0.49 | 97 | | | | |
| Tl(ppb)* | 0.81 | 0.24 | 96 | | | | |
| Zn(ppm) | 43 | 53 | 96 | | | | |
| Cd(ppb) | 0.72 | 3.7 | 99 | Cd(ppb) | 1.6 | 14.2 | 99 |

* Arithmetic means: all others are geometric means.

[†] Column headings: Ant - Antarctic chondrites from Victoria Land; Non - Non-Antarctic chondrite falls; Sig. - Significance level at which it may be concluded that the respective sample populations do not derive from the same parent population. Numbers in parentheses are number of samples analyzed in that population.

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Properties of Antarctic finds and non-Antarctic falls differ to degrees well beyond those expected to arise from weathering [4]. Differences more subtle than those in Table 1 are apparent when trace element contents of H5 or L6 chondrites from Victoria Land are compared with respective non-Antarctic falls. Using normal or lognormal distributions and standard statistical tests, 8 of 13 elements differ at >90% confidence level in each population (Table 2). [Furthermore, the differences are apparent in all equilibrated H and L chondrites, at least.] While elements that differ overlap to some extent, those that do differ in direction. From these and other data cited earlier, we can show that differences do not reflect Antarctic weathering or incidental causes (sample selection bias, compositional modeling, analytical bias or chance) [4,8].

We interpret compositional differences as reflecting derivation of Antarctic meteorites predominantly from parent sources or regions different than those from which contemporary falls derive. Hence, the near-earth meteoroid complex sampled by Victoria Land 3×10^5 years ago differed from that sampled today [4]. For example, the Victoria Land L6 chondrite sample population predominantly derived from a body or region much more heavily shocked, on average, than the one(s) we now study through contemporary L chondrites [8]. Antarctic meteorites truly constitute a solar system snapshot in time and/or space.

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